Geology and Geochemistry Investigation of Banded Iron Formations from Haraginadoni Copper Mountain Range of Sandur Greenstone Belt, Dharwar Craton, India

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Abstract : The banded iron formations (BIF) form a strange part of the Sandur greenstone belt of Dharwar craton in Archean Indian Shield, which are exposed around the Haraginadoni area. The iron and manganese ores are limited in the Copper Mountain range. The Sandur greenstone belt constituting lithostratigraphically a formal unit of a group is a part of the Precambrian supracrustal belts in the Dharwar craton of South India (2900 to 2600 my). In Sandur greenstone belt the iron and manganese deposits are concentrated along the hilltop and ridges ranging between 600 to 1100 m in altitude. A geological map is the most fundamental prerequisite in any geological investigations. A detailed and systematic geological mapping has been carried out using geoinformatics tools. The BIF of the study area form a part of the Sandur greenstone belt which is considered to be the younger greenstone belt. It is structurally highly disturbed and squeezed out of shape by the intrusion of younger closepet granites. It consists of basic igneous rocks, arenaceous, argillaceous and ferruginous (BIF) sediments. The iron formations of the present study area, the Haraginadoni area forms the north-eastern edge of the Sandur greenstone belt and it is characterised by number of iron ore deposits. The iron ore deposits are associated with banded hematite quartzite/jasper and at places with shales and phyllites. The major rock types of the study area are banded iron formation, chlorite schist, meta-basalt, gneisses, granites, laterites and intrusive dykes. The geochemical analysis reveals that, the presence of average major element values of oxide facies BIF Algoma type, superior type, Achaean, Proterozoic and Orissa. Investigated area is predominantly characterised by iron and silica is higher and Fe_2O_3, Al_2O_3, CaO and MgO are low in their values. K_2O and Na_2O content of the BIF of the analysis area shows close proximity of the superior type. The investigation is confirming that, the BIF of the study area are geochemically more or less in similar to the Precambrian BIF of the other parts of the world and BIF of the Orissa.

IndexTerms **- Haraginadoni BIF, Sandur greenstone belt, iron ore, Geoinformatics.**

I. INTRODUCTION

The study of banded iron formation (BIF) and iron ores have attracted the attention of geoscientist all over the world, not only because of the fact that they form the back bone of the economic development of the country but also for the interesting ideas on their nature of the source rock, depositional characters, stratigraphy, structure, mineralogy, tectonics, geochemistry, diagenesis and history of metamorphism which are inconclusive even to this day.

A good number of researchers since 1838 have worked on various lithological units of Haraginadoni area with special reference to the Sandur greenstone belt, but a very few have done studies on the copper mountain range. Captain Newbold (1842) was the first to traverse various part of Sandur greenstone belt to study the rock formations. He has reported copper mineralization at the Sugalammadevi Konda area of copper mountain range. Bruce Foote (1895) identified granites, gneisses and schistose formations of the Sandur greenstone belt and he found the traces of copper mineralization in old workings in the shallow caves of the copper mountain range. Geologically BIFs have been on the basis of their tectonic setting and depositional geo-environment (Gross, 1959, 1965, 1980, 1986). Sadasivaiah et.al. (1976) have given an account of the occurrences of aegirine and riebeckite in the BIF of southern part of the copper mountain range. They have concluded that thin ferruginous layers containing aegirine and riebeckite are metasomatic in origin. Sadasivaiah and Karisiddaiah (1976) have reported the presence of diabase dyke at Haraginadoni area of the copper mountain range. Roy and Biswas (1983) have studied structures of the Sandur greenstone belt. According to them copper mountain range is a syncline plunging towards north-west at moderate angle 35°. To the south of Copper Mountain, there are two subsidiary folds, a syncline and an anticline, the characteristic of en-echelon type macroscopic fold.

The Sandur greenstone belt is one of the important greenstone belts in Dharwar craton of Karnataka. The belt has been of focal point and has drawn the attention of geologists and researchers from time to time as the belt consists of rich deposits of iron and manganese ores which are of great economic importance to the country.

Scanning through the literature available on the Sandur greenstone belt, it is clear that most of the research work is concentrated on the south-west and north-west portions of the greenstone belt.

In the current research work, the BIF and iron ores of Haraginadoni copper mountain range were studied which belongs to south-eastern part of the greenstone belt. The literature on geology of this part of the greenstone belt is scanty. Keeping this in view, the authors has under taken research work on this area and an attempt has been made to understand the geology and geochemistry aspects of the banded iron formations and associated iron ores.

II. LOCATION OF THE STUDY AREA

The area under investigations forms the south-eastern part of the Sandur greenstone belt and lies between longitude 76°45’00” to 76°52’40” East and latitude 15°00” to 15°9’30” North **“Map. 1”**. The area is found in the Survey of India toposheet No. 57A/16 which include part of Ballari district of Karnataka and part of Ananthpur district of Andra Pradesh states. The area is accessible from Haraginadoni which is about 16 km west of Ballari, walk of 6 to 7 km towards north-western part to reach the study area.

There are unmetal roads to reach interior part where labour quaters of iron ore mines are located. Apart from these, there is a metre gauge railway track from Ballari to Rayadurga and nearest station is Halakundi.

III. Method of research work

Basavaraj Hutti and Nijagunappa (2011; 2012; 2015), are acknowledged using geoinformatics technology a geological map is the most fundamental prerequisite in any geological investigation. The study area is about 75 km^2. A systematic geological mapping has been carried out using Geoinformatics tools such as MapInfo Pro version, AutoCAD-MAP, Garmin GPS and Google Earth. In additional to this, Google Earth satellite image data is also used to delineate the regional lineaments of the study area. During geological mapping, a large number of fresh outcrop samples, ores were identified and collected from the in-situ outcrops.

Five representative samples of banded iron-formation from the different locations of the study area have been analysed for major elements using Atomic Absorption Spectra photometer and the wet chemical method at the chemical laboratory of NMDC, Donimalai.

IV. Geological study of the area

The Sandur greenstone belt is one of the greenstone belts developed in the western iron and manganese provenance covering an area about 1000 km2. The Sandur greenstone belt constituting lithostratigraphically a formal unit of a group is part of the Dharwar craton which has been given the status of a super group and the greenstone belt within the range of 2500 to 3000 my. In the absence of reliable geochronological data on the rocks of this area, it is difficult to fix absolute ages for various lithological units. However, based on the lithological similarities and the ore associations this group can be approximately equated with Bababudan and Dodguni series (Radhakrishna, 1983). The Sandur greenstone belongs to the younger greenstone group (Dharwar type). The bulk of schistose formations described in earlier literature (Fermer, 1936; Rama Rao, 1940; Nautiyal, 1966; Pitchamuthu, 1947, 1967, 1983; Radhakrishna, 1964, 1967; Srinivas and Srinivasan, 1972; Naqvi et.al., 1974; Iyengar, 1976; Swainath, 1976; Radhakrishna and Vasudeva, 1977; Swaminath and Ramakrishna, 1981; Roy and Biswas, 1983; Pitchuttu et.al., 1983; Mishra, 1985) as Dharwar craton fall within the younger greenstone group.

The Sandur greenstone belt is boat shaped valley surrounded by hill ranges. The hill ranges and the contained valley constitute the “Sandur Synclinorium” plunging at 23° of N40°W, where strata have been tightly folded into isoclinals overturned folds (Mishra, 1976). The weathering cycle have carved out valleys in the anticlines and hills in the synclines and the in-situ ore bodies are located at the crest of the synclinal hills.

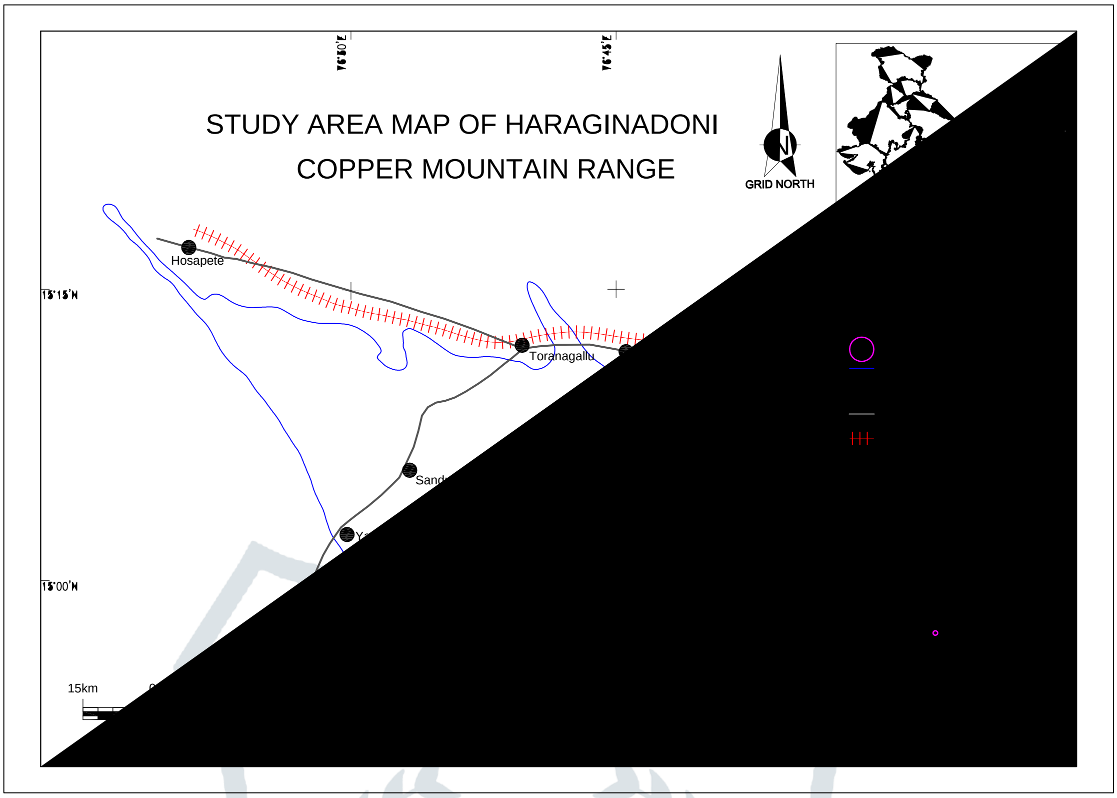
According to Mishra (1976), order of superposition of rocks in the Sandur group of the Dharwar super group craton indicates a typically eu-geosynclinal succession. The lowest horizon comprises lava flow (now chlorite schist) with a few intercalated lenticular bands of conglomerate and banded magnetite chert/quartzite. This has been non conformably overlain by the argillite facies (Phyllite etc.) and after an off-lap, passes in to an arenite facies represented by banded hematite chert/quartzite/jasper with some intercalations of ferruginous shales. The sequence is topped by oxihydroxide mineral assemblage of iorn, constituting the iron ore deposits.

The current research work of Haraginadoni area forms a part of the Copper Mountain Range which is a south-western part of the Sandur greenstone belt. The major rock types of the study area are banded iron formation, chlorite schist, metabasalt, gneisses, granites, laterites and intrusive dykes **“Map. 2”**.

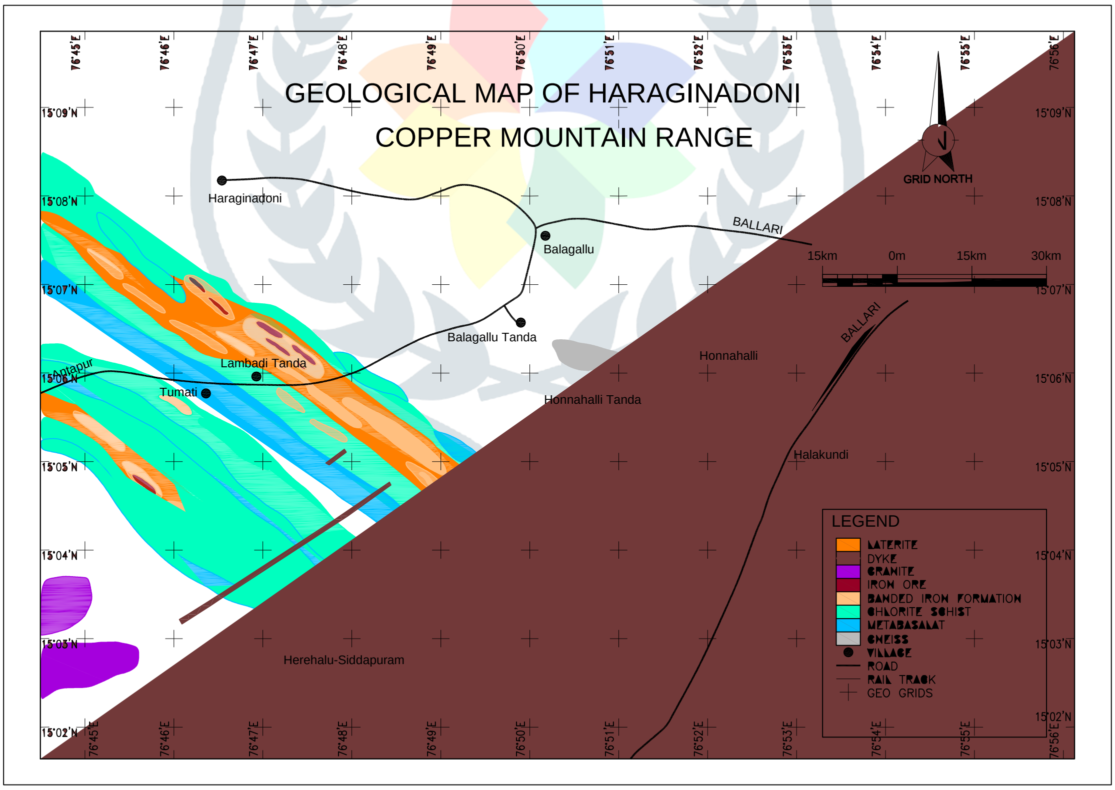
The Haragindoni area in the Copper Mountin Range is characterised by number of hills. BIF is the chief lithological unit of the area. BIF is exposed on the top of the hill ranges, chlorite schist is exposed conformably adjacent to the BIF long the slopes and foot hill rages. At the foot hills of the hill ranges and nalla cuttings, metabaslts were observed. Granites are intruded into the chlorite schist, which is very well exposed around the Haraginadoni area.

V. Geochemistry analysis

Five representative samples of banded iron-formations from the different locations of the study area have been analysed for major elements using Atomic Absorption Spectro photometer. The investigated data has been presented in the **Table. 1**. The average major element values of oxide facies BIF of Algoma type, Superior type, Archaean, Proterozoic and Orissa are also presented in the **Table. 2** for comparison. The BIF of the study area is characterized by predominance of iron and silica and higher Fe_2O_3, Al_2O_3, CaO and MgO are low in their values and this reflects the scare occurrence of silicate and carbonate minerals. The value of Al_2O_3, MgO, CaO and P_2O_5 are low compared to Superior and Algoma type. Gross, et. al., (1980) while presenting the chemical composition of iron formation of Canada noticed that these values of Algoma facies of iron formation is at least twice that of the Superior facies of iron formation. However, the K_2O and Na_2O content of the BIF of the study area show close proximity of the Superior type. The average values of Al_2O_3, Fe_2O_3 and SiO_2 and Fe, CaO + MgO and SiO_2 of the study area when plotted on the triangular diagrams of Govett, (1960) and Lepp & Goldich, (1964) **“Fig. 1”** they lie within the Precambrian field. Thus confirming the fact that BIF of the area is geochemically similar to the Precambrian BIF of other parts of the world. When the average values of BIF of the Archean, Proterozoic, Superior type, Algoma type, Eastern India and the study area are plotted against the respective oxide percentages, it is observed that there is no significant variation in respect of any of the elements except MgO, CaO and $Al2O_3$. The values of BIF of the Orissa and study area are more or less same.



Map. 1: Location of the study area of Haraginadoni copper mountain range



Map. 2: Geological map of Haraginadoni copper mountain range

Table. 1: Major element constituents of BIF in the Haraginadoni Copper Mountain Range of Sandur green stone belt.

Sample	Fe_2O_3	SiO_2	Al_2O_3	TiO_2	FeO	MnO	MgO	CaO	K_2O	Na_2O	P_2O_5	LiO	Total
HCMR01	48.05	50.5	0.63	0.04	0.15	0.02	0.12	0.21	Trace	0.1	0.009	0.11	99.94
HCMR02	47.48	49	0.6	0.29	0.9	0.05	0.34	0.31	0.1	0.21	0.011	0.39	99.68
HCMR03	47.11	51.18	0.64	0.03	0.16	0.03	0.22	0.12	Trace	0.1	0.008	0.31	99.91
HCMR04	54.33	41.9	0.56	0.4	0.5	0.78	0.68	0.37	Trace	Trace	0.047	0.41	99.98
HCMR05	47.02	50.2	0.68	0.09	0.12	0.02	0.24	0.9	Trace	0.12	0.01	0.32	99.72
HCMR06	48.02	49.4	0.62	0.08	0.16	0.05	0.13	0.19	0.05	0.09	0.007	0.23	99.03
HCMR07	48.05	49.02	0.61	0.21	0.8	0.04	0.36	0.28	Trace	Trace	0.015	0.52	99.91
HCMR08	48.11	50.38	0.66	0.01	0.18	0.01	0.12	0.16	0.02	Trace	0.009	0.3	99.96
HCMR09	47.36	48.66	0.58	0.6	0.83	0.59	0.67	0.29	Trace	0.23	0.035	0.14	99.99
HCMR10	49.23	47.03	0.53	0.19	0.24	0.09	0.36	0.8	Trace	0.18	0.046	0.41	99.11

Table. 2: A geochemical major elements (wt %) comparison with the BIF of Haraginadoni Copper Mountain Range from the BIF of other parts of the world.

Elements	HCMR BIF	Orissa BIF	Lake Superior oxide facies BIF	Algoma oxide facies BIF	Archaean oxide facies BIF	Proteriozoic oxide BIF
SiO_2	48.472	47.02	47.20	50.50	47.30	46.90
Al_2O_3	0.622	0.70	1.39	3.00	1.25	1.15
Fe_2O_3	48.790	44.16	35.40	26.90	22.94	18.08
FeO	0.384	8.28	8.20	13.00	20.50	23.11
MnO	0.180	0.06	0.73	0.22	0.59	0.59
CaO	0.382	0.17	1.58	1.51	2.84	4.43
MgO	0.320	0.13	1.24	1.53	3.66	4.41
Na_2O	0.132	0.10	0.12	0.31	0.22	0.29
K_2O	0.100	0.13	0.14	0.58	0.09	0.48
H_2O	ND	1.94	1.30	1.10	ND	ND
P_2O_5	0.017	0.07	0.06	0.21	0.22	0.14
CO	ND	ND	3.00	1.10	ND	ND
S	ND	ND	0.02	0.29	ND	ND

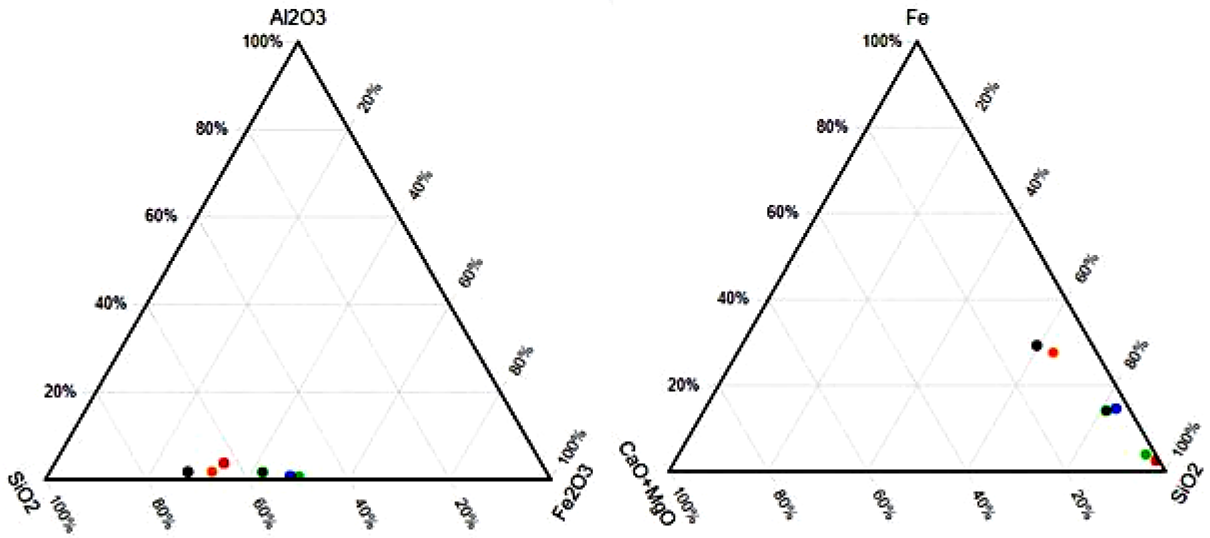


Fig. 1: The average values of Al_2O_3, Fe_2O_3 and SiO_2 and Fe, CaO + MgO and SiO_2 of the study area when plotted on the ternary diagrams

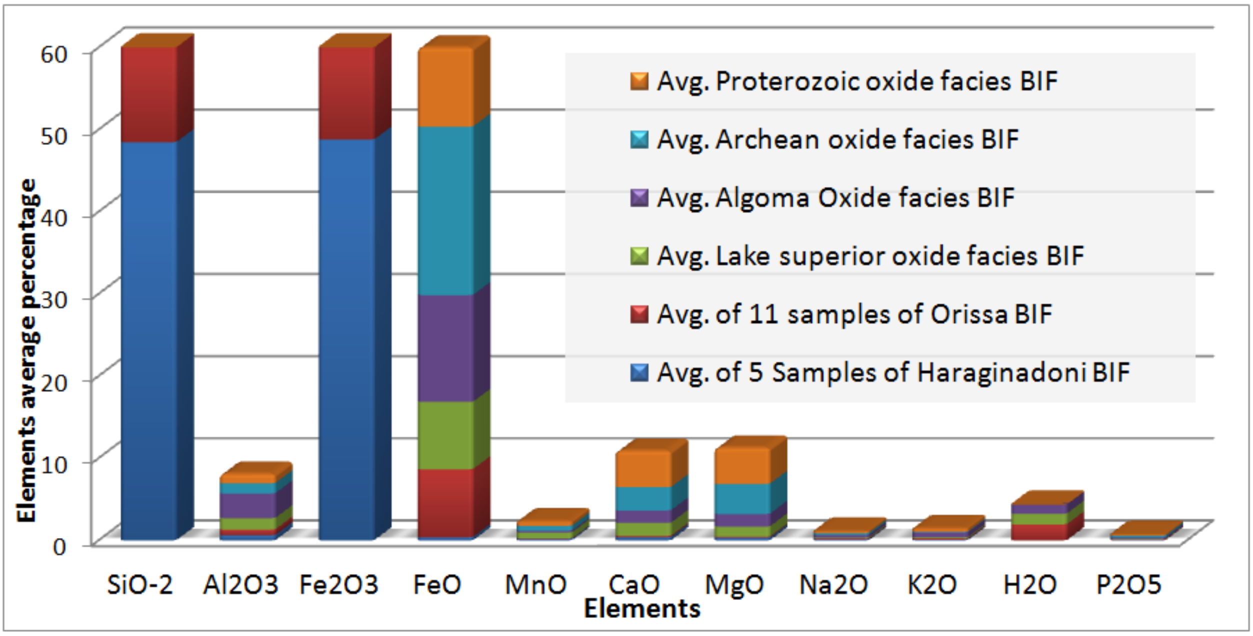


Fig. 2: A geochemical major elements (wt %) comparison with the BIF of Haraginadoni Copper Mountain Range from the BIF of other parts of the world.

VI. Observations

Major elemental studies favours that the BIFs are of Precambrian in age representing late Archaean to early Proterozoic period. The low values of Al_2O_3, CaO and MgO have been noticed. The low alumina content compared to high iron is the important factor to be considered while discussing the sources of the BIFs. The available information on the BIFs of the study area favours the volcanic exhalative source. Continental weathering has also played a role in deriving the iron and silica to the sites of deposition, but it is insufficient. The deposition of iron-formations are mainly controlled by seasonal climatic variations and cyclic variation in basinal chemistry. The iron ore of the area mainly formed by the leaching of silica from BIF and the residual enrichment of the iron. This has been guided by the pH and Eh of the solution and mobility factor of the iron compared to silica and alumina.

VII. Conclusions

Based on the field geological and geochemical observations on the banded iron formations of the Haraginadoni Copper Mountain Range, the following conclusions have been drawn.

- The banded iron formations of the area are of chemical precipitates and the deposition took place during late Archaean to Early proterozoic period i.e. 2900-2600 my.
- Major elements analysis reveals that BIFs of the area are low in Al_2O_3, CaO, and MgO content and the ternary diagram of Lepp & Goldich and Govett fits into the field of Precambrian.
- Volcanic exhalative and continental weatherings have contributed the iron and silica to the sites of deposition.
- The iron ores which are closely associated with the BIFs are derived from the leaching of silica from BIFs and its residual enrichment under varying Eh and PH condition.

References

[1]. Basavaraj, Hutti and Nijagunappa, R., (2011): Development of Groundwater Potential Zone in North-Karnataka Semi-Arid Region Using Geoinformatics Technology, Universal Journal of Environmental Research and Technology, Euresian Publications, Volume 1, Issue 4: 500-514.

[2]. Basavaraj, Hutti and Nijagunappa, R., (2011): Geoinformatics Technology Application in North Karnataka for Water Resources Management, Universal Journal of Environmental Research and Technology, Euresian Publications, Volume 1, Issue 3: 222-232.

[3]. Basavaraj, Hutti and Nijagunappa, R., (2012): Geoinformatics Based Decision Support System Tools for Water Resources Management in North Karnataka, India, International Bimonthly, Indian Journal of Natural Sciences, Volume 2 Issue 10 pp.779-791.

[4]. Basavaraj, Hutti and Nijagunappa, R., (2011): Identification of Groundwater Potential Zone using Geoinformatics in Ghataprabha basin, North Karnataka, India, International journal of geomatics and geosciences, Integrated Publications, Volume 2, No 1, pp.91-109.

[5]. Basavaraj, Hutti and Nijagunappa, R., (2011): Applications of Geoinformatics in Water Resources Management of Semi-Arid Region, North Karnataka, India, International journal of geomatics and geosciences, Integrated Publications, Volume 2, No 2, pp.371-382.

[6]. Basavaraj Hutti and Basavarajappa. H.T, (2014): Assessment of River Basin for Engineering Restoration in Ghataprabha Catchments using Geo-informatics Applications. International journal of Computer Engineering & Technology (IJCET). Volume 5, Issue 1, pp.94-102. ISSN 0976 – 6367(Print) ISSN 0976 – 6375(Online)

[7]. Bruce Foote, R., (1895): Geology of Bellary Dist. GSI Memoir V.25.

[8]. Captain Newbold, J.J., (1842): Notes Principally Geological, on the tract between Bellary and Biapur, Journal Asia. Soc. Bengal. IX.

[9]. Fermer, L.L., (1936): An attempt at the correlation of the Ancient schistose formations of peninsular India. Mem. GSI. V.70, pp. 1-52.

[10]. Gross, G.A., (1959): A classification of iron deposits in Canada. Cana. Min. Jour., V.80, pp. 187-192.

[11]. Gross, G.A., (1965): Geology of iron deposits in Canada. 1. General geology and evaluation of iron deposits. Geol. Surv. Can. Econ. Geol. Rep., 22: 181.

[12]. Gross, G.A., (1980): A classification of iron-Formation Based on Depositional Environment. Canadian Mineral., V.9. pp. 215-222.

[13]. Gross, G.A., (1986): The metallogenetic Significance of Iron-Formation and related stratafer Rocks., Jour. G.S. India, V.28., pp. 92-108.

[14]. Iyengar, S.V.P., (1976): The stratigraphy, structure and correlation of the Dharwar Super group. GSI. Misc. Publ. V.23, pp. 515-55.

[15]. James, (1954): Sedimentary facies of iron-formation. Econ. Geol., V.49, pp. 235-293.

[16]. Mishra, R.N., (1976): Iron ore deposits of Bellary-Hospet Region. Proc. Symp. Geol. Etc., of ferrous and ferro-alloy minerals, pp. 4549.

[17]. Mishra, R.N., (1985): Chitradurga metallogeny a case study for regional metallogenic analysis. Jour. Geol. Soc. India, V.26, pp. 599-606.

[18]. Naqvi, S.M., Devakara Rao, V., and Hari Nain., (1974): Precambrian of Mysore Plateau, Presidential address. Proc. 53rd Indian Sci. Congr., pp. 1-14.

[19]. Nautiyal, S.P., (1966): Precambrian of Mysore Plateau, Presidential address. Proc. 53rd Indian Sci. Congr., pp. 1-14.

[20]. Pitchamuthu, C.S., (1947): Some aspect of Dharwar geology with special reff. To Mysore state. Presidential address. Proc. 34th Indian Sci. Congr. Delhi., pp. 1-16.

[21]. Pitchamuthu, C.S., (1967): The precambrians of India. The Geol. System. The precmbrian, interscience, New Yark, V.3, pp. 1-96.

[22]. Pitchamuthu, C.S., (1983): A billion years history of the Dharwar Craton (3200-2100 m.y. ago). Precambrian of South India. Mem. GSI. V.4, pp. 121-142.

[23]. Radhakrishna, B.P., (1964): Some aspect of the stratigraphy and structure of Dharwar of Mysore state. Proc. Symp. Stratigraphy etc., of the Archaean provinces of India. V.8, p. 102.

[24]. Radhakrishna, B.P., (1967): Reconsideration of some problems in the Archaean Complex of Mysore. Jour. GSI, V.17, pp. 79-88.

[25]. Radhakrishna, B.P., (1983): Archaean granite-greenstone terrain of the south Indian shield, Precambrian of south India, Mem. GSI., V.4., p. 275.

[26]. Radhakrishna, B.P., and Vasudeva, V.N., (1977): The early Precambrian of the southern Indian shield, Jour. GSI. V.18, pp. 525-541.

[27]. Rama Rao, B., (1940): Archaean complex of Mysore. Bull. Myso. Geol. Dept. No.17., p.95.

[28]. Roy, A., and Biswas, A.K., (1983): Stratigraphy and structure of Sandur schist belt, Karnataka. Jour. Of GSI. V.24, No.1., pp. 19-28.

[29]. Sadasivaiah, M.S., and Karisiddaiah, S.M., (1976): Occurrence of Aegirine and Riebeckite in the Banded Ferruginious Quartzite of Sanjeevarayanakota. Bellary. Karnataka., Jour., of Karn., uni. V.21., pp. 65-70.

[30]. Sadasivaiah, M.S., and Karisiddaiah, S.M., (1976): Occurrence of Aegirine and Riebeckite in the Banded Ferruginious Quartzite of Sanjeevarayanakota. Bellary. Karnataka., Jour., of Karn., uni. V.21., pp. 65-70.

[31]. Srinivas, R., and Srinivasan, B.L., (1972): Dharwar stratigraphy, Jour. GSI, V.13, pp. 75-85.

[32]. Swainath, J., Ramakrishna, M., and Vishwanatha, M.N., (1976): Dharwar stratigraphic model and Karnataka Catonic evolution. Rec. GSI, V.107, pp. 149-175.

[33]. Swaminath, J, and Ramakrishna, M., (1981): Early Precambrian supracrustals of southern Karnataka., Mem. GSI, V.112, pp. 1-350